

Figure 1A
(Prior Art)

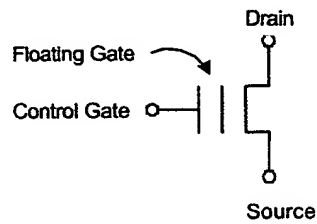


Figure 1B
(Prior Art)

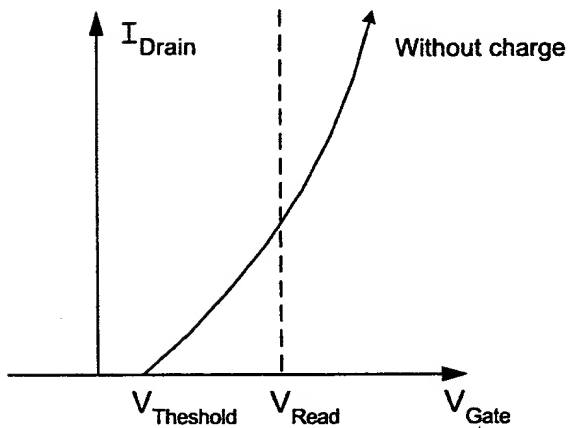


Figure 1C
(Prior Art)

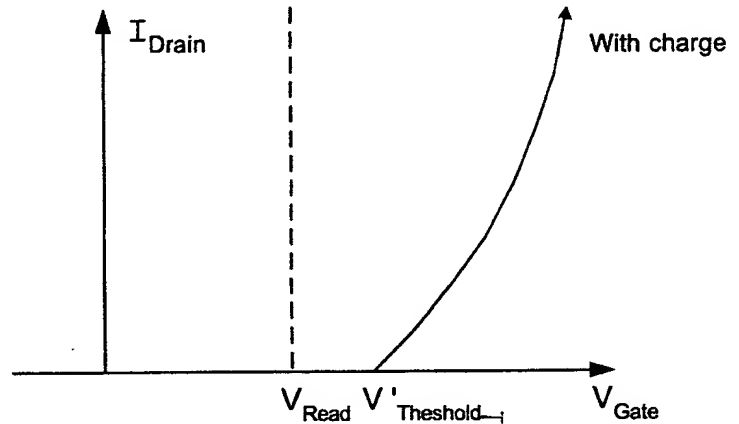


Figure 1D
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Calculation of nv memory cell retention characteristics

Seconds
31536000
94608000
1.89E+008
2.84E+017
3.78E+008
4.73E+008
9.08E+009
6.62E+008
7.57E+008
8.51E+008
9.46E+008

Time Period
1 year
3 years
6 years
9 years
12 years
15 years
18 years
21 years
24 years
27 years
30 years

m0, kg
1.6022E-019
9.1095E-031
1.38062E-023
6.62617E-034
1.054568E-034

kb, J/K
h_i, J-s
hb, J-s

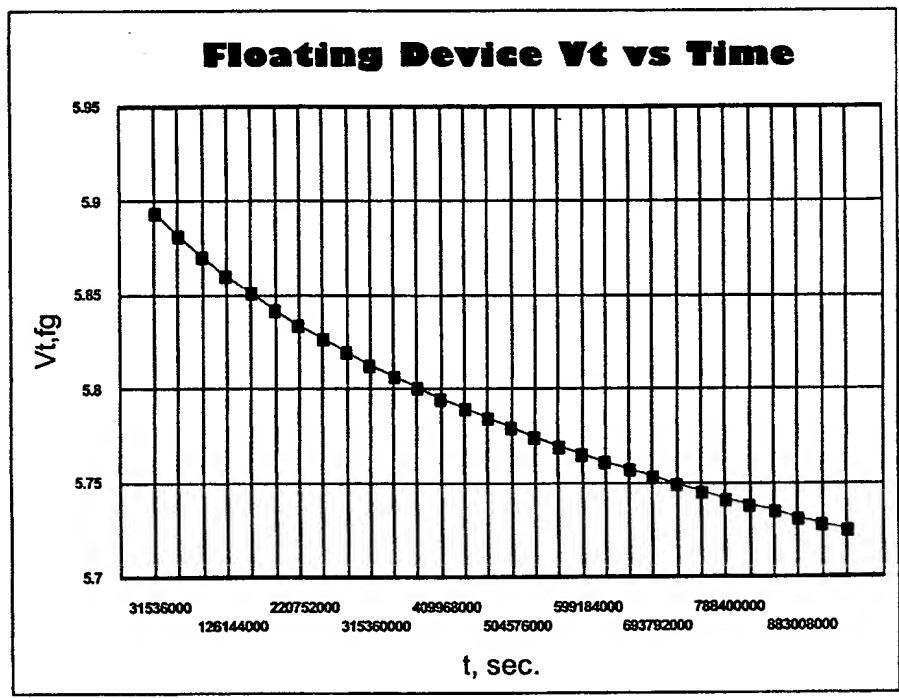
mr, effective mass ratio
T, K degree
300

C
1.0630E-006
2.3854E+008

Lfg um 0.6000
Wfg um 1000.0000
Hfg um 0.0900
Wrx um 0.5000
Ttunox A 80
Tono A 190
Tswox A 300
Xfd um 0.0500
Xfs um 0.3500
Ainj um2 0.0438
Cfc fF 1089.5358
Cfsx fF 0.4313
Cfd fF 0.1078
Cfs fF 0.7547
Cfg fF 1090.8295
Cr,wl 0.9988
Cr,src 0.0007
Vt,fg V 0.90
Verase 0.00
Vfg,ini -5.00
Va 0.00
S 3.76E+016
X 1.27E+011

Channel length of floating gate device
Channel width of floating gate device.
Thickness of floating gate polysilicon conductor
Width of floating gate overlapping shallow trench isolation
Tunnel oxide thickness
Thickness of Oxide-Nitride-Oxide dielectric between floating gate and control gate for capacitive coupling
Thickness of sidewall oxide between floating gate and control gate for sidewall coupling
Length of floating gate overlapping drain region of the floating gate MOSFET
Length of floating gate overlapping source region of the floating gate MOSFET
Area of the electron tunneling region between the floating gate and the source for resetting the floating gate charge
Capacitance between the floating gate and the control gate
Capacitance between the floating gate and the silicon substrate
Capacitance between the floating gate and the drain
Capacitance between the floating gate and the source
Total floating gate capacitance
Control gate to floating gate coupling ratio
Source junction to floating gate coupling ratio
Threshold voltage of floating gate MOSFET
Erase voltage applied to the source(not used here, set to zero)
Initial floating charged voltage
Actual erase volatge (equal to applied + charge stored on the floating)
Derived parameter in the floating gate "erase" equation
Derived parameter in the floating gate "erase" equation

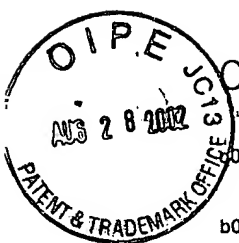
t, sec.	Vt,fg
0.00001	5.907
31536000	5.894
63072000	5.882
94608000	5.871
1.26E+008	5.861
1.58E+008	5.852
1.89E+008	5.843
2.21E+008	5.835
2.52E+008	5.827
2.84E+008	5.820
3.15E+008	5.814
3.47E+008	5.807
3.78E+008	5.801
4.1E+008	5.795
4.42E+008	5.790
4.73E+008	5.785
5.05E+008	5.780
5.36E+008	5.775
5.68E+008	5.770
5.99E+008	5.766
6.31E+008	5.762
6.62E+008	5.757
6.94E+008	5.753
7.25E+008	5.750
7.57E+008	5.746
7.88E+008	5.742
8.2E+008	5.739
8.51E+008	5.735
8.83E+008	5.732
9.15E+008	5.729
9.46E+008	5.726



Figures 1E-1F
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Calculation of memory cell retention characteristics

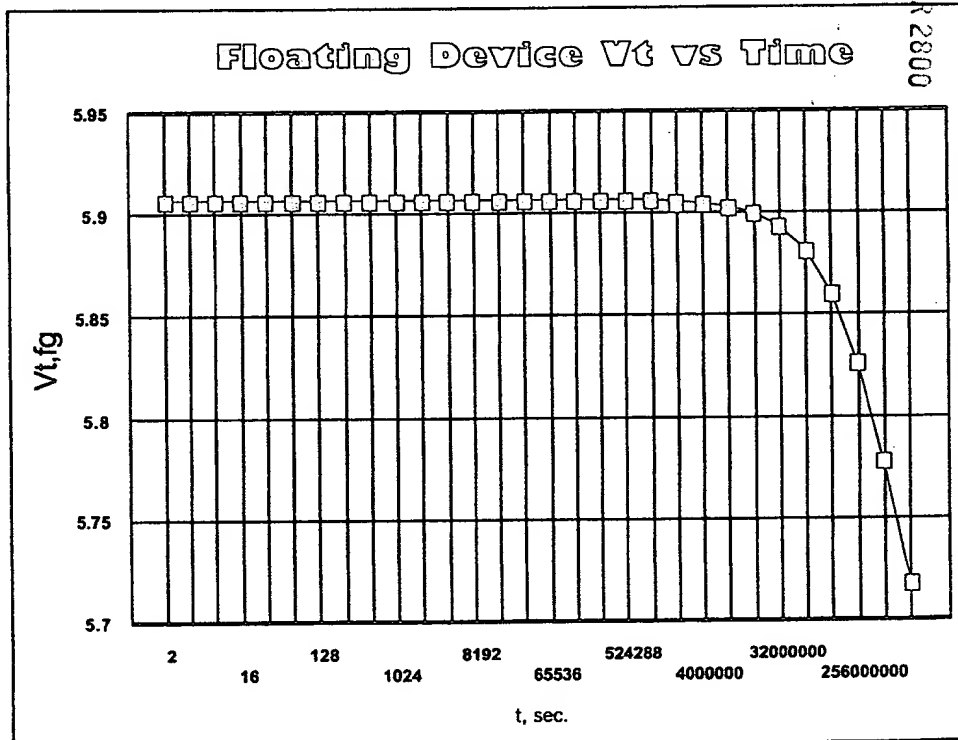
Q, C 1.6022E-019 m0, kg 9.1095E-031 kb, J/K 1.38062E-023 h, J-s 6.62617E-034 hb, J-s
b0, eV (barrier) ϵ l 2.9 mr, effective mass ratio 3.9 0.5 T, K degree 300
C 1.0630E-006 b 2.3854E+008

Seconds	Time Period
60	1 minute
3600	1 hour
86400	1 day
604800	1 week
2592000	1 month
.....	1 year
.....	4 years
.....	16 years
.....	32 years

Lfg um 0.6000 Channel length of floating gate device
Wfg um 1000.0000 Channel width of floating gate device.
Hfg um 0.0900 Thickness of floating gate polysilicon conductor
Wrx um 0.5000 Width of floating gate overlapping shallow trench isolation
Ttunox A 80 Tunnel oxide thickness
Tono A 190 Thickness of Oxide-Nitride-Oxide dielectric between floating gate and control gate for capacitive coupling
Tswox A 300 Thickness of sidewall oxide between floating gate and control gate for sidewall coupling
Xfd um 0.0500 Length of floating gate overlapping drain region of the floating gate MOSFET
Xfs um 0.3500 Length of floating gate overlapping source region of the floating gate MOSFET
Ainj um² 0.0438 Area of the electron tunneling region between the floating gate and the source for resetting the floating gate charge
Cfc fF 1089.5358 Capacitance between the floating gate and the control gate
Cfsx fF 0.4313 Capacitance between the floating gate and the silicon substrate
Cfd fF 0.1078 Capacitance between the floating gate and the drain
Cfs fF 0.7547 Capacitance between the floating gate and the source
Cfg fF 1090.8295 Total floating gate capacitance
Cr,wl 0.9988 Control gate to floating gate coupling ratio
Cr,src 0.0007 Source junction to floating gate coupling ratio

Vt,fg V 0.90 Threshold voltage of floating gate MOSFET
Verase 0.00 Erase voltage applied to the source(not used here, set to zero)
Vfg,ini -5.00 Initial floating charged voltage
Va 0.00 Actual erase volatge (equal to applied + charge stored on the floating)
S 3.76E+016 Derived parameter in the floating gate "erase" equation
X 1.27E+011 Derived parameter in the floating gate "erase" equation

t, sec.	Vt,fg
0.00001	5.907
2	5.907
4	5.907
8	5.907
16	5.907
32	5.907
64	5.907
128	5.907
256	5.907
512	5.907
1024	5.907
2048	5.907
4096	5.907
8192	5.907
16384	5.907
32768	5.907
65536	5.907
131072	5.907
262144	5.907
524288	5.907
1000000	5.907
2000000	5.906
4000000	5.905
8000000	5.904
16000000	5.900
32000000	5.894
64000000	5.881
.....	5.860
.....	5.827
.....	5.779
.....	5.718



Figures 1G-1H
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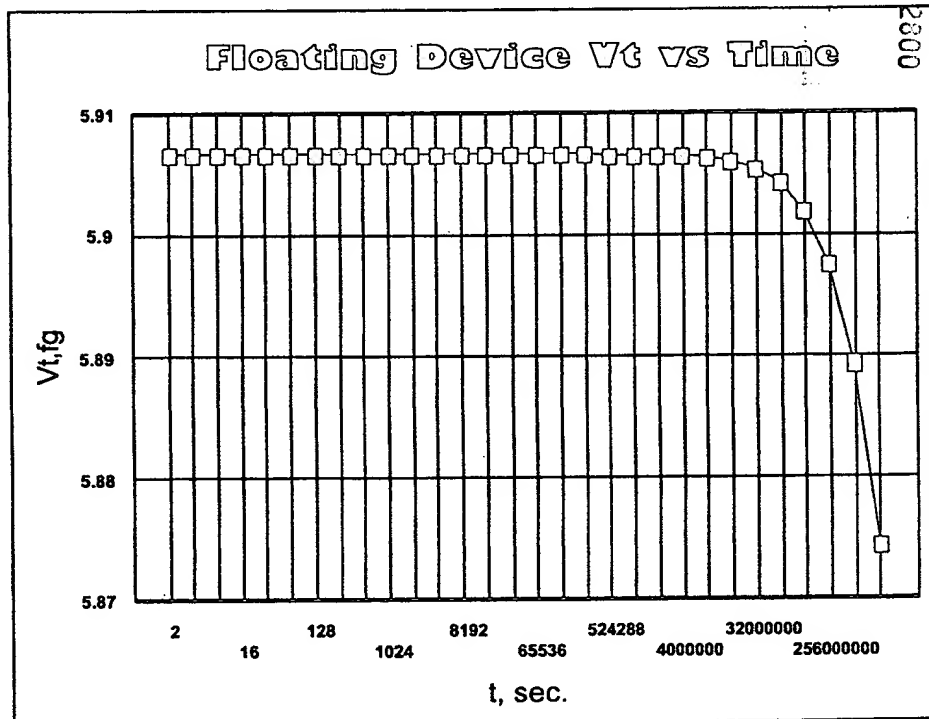
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b0, eV (barrier) 2.9 mr, effective mass ratio 3.9 0.5 T, K degree 300
C 1.0630E-006 b 2.3854E+008

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2592000 1 month
..... 1 year
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Cfc fF 1089.5358 Capacitance between the floating gate and the control gate
Cfsx fF 0.4059 Capacitance between the floating gate and the silicon substrate
Cfd fF 0.1015 Capacitance between the floating gate and the drain
Cfs fF 0.7103 Capacitance between the floating gate and the source
Cfg fF 1090.7534 Total floating gate capacitance
Cr,wl 0.9989 Control gate to floating gate coupling ratio
Cr,src 0.0007 Source junction to floating gate coupling ratio
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Verase 0.00 Erase voltage applied to the source(not used here, set to zero)
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X 1.20E+011 Derived parameter in the floating gate "erase" equation

t, sec.	Vt,fg
0.00001	5.907
2	5.907
4	5.907
8	5.907
16	5.907
32	5.907
64	5.907
128	5.907
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2048	5.907
4096	5.907
8192	5.907
16384	5.907
32768	5.907
65536	5.907
131072	5.907
262144	5.907
524288	5.907
1000000	5.907
2000000	5.907
4000000	5.906
8000000	5.906
1.6E+007	5.906
3.2E+007	5.905
6.4E+007	5.904
.....	5.902
.....	5.898
.....	5.889
.....	5.874



Figures 11-1J)
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